Center Innovation Fund: KSC CIF

Magnetic De-spinning of Space Objects

Completed Technology Project (2016 - 2017)

Project Introduction

Objects in orbit about the earth rotate such that a service spacecraft cannot grapple to them. There are few techniques available to despin a space object without damaging it so that grappling can occur. Electrostatic approaches have been considered, but magnetic approaches have not been sufficiently studied. The basic theory has been developed by the PI and partners when the space object can be modeled as a hollow sphere. Need to explore the parameter space and study a variety of magnetic configurations, large weak fields versus small intense fields and steady state versus time varying. Need to account for orbital dynamics and approach range and time scale issues.

Both NASA and the military have future requirements where a satellite must mate to a tumbling space item. NASA would like to refuel defunct satellites (this was an early requirement of the Restore Project) and attach to small asteroids, while the military would like to deorbit space debris without creating more debris. In all cases, a grappling satellite must connect with a tumbling item without causing damage to either itself or the item.

One possible way to do this is to use magnetic fields to induce a de-spinning torque, slowing the tumbling item down until mating can occur. We have shown theoretically and through tabletop experiments that this concept has merit and is deserving of further study. The proposed project would have Youngquist and Nurge predict the lateral forces and torques created under various scenarios and then have orbital dynamics experts, Professor Mason Peck of Cornell University and Dr. Frederick Leve of the Air Force Research Lab (AFRL), determine the relative motion and response of each of the interacting objects.

The goal of this work is to develop a methodology for determining what magnetic field and orbital configuration is optimal to de-spin various space objects; should large, but weak, magnetic fields be used versus small, strong fields? What is the time scale of the de-spinning process? How is conservation of angular momentum resolved between the satellite and the tumbling object? What relative orbit should be used to help resolve induced lateral forces? Answering these questions will pave the way for the eventual implementation of this concept.

Anticipated Benefits

Repair/refuel defunct spacecraft, Deorbit space debris safely. NASA missions will eventually need to attach a satellite to a tumbling object, be it a defunct vehicle or a small asteroid. Trying to attach to the object while it is tumbling will likely lead to damage, so an approach is required to de-spin the object.

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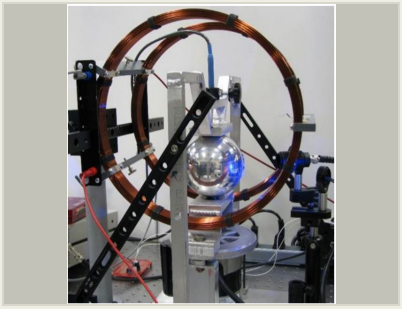

Aluminum sphere in a uniform magnetic field.

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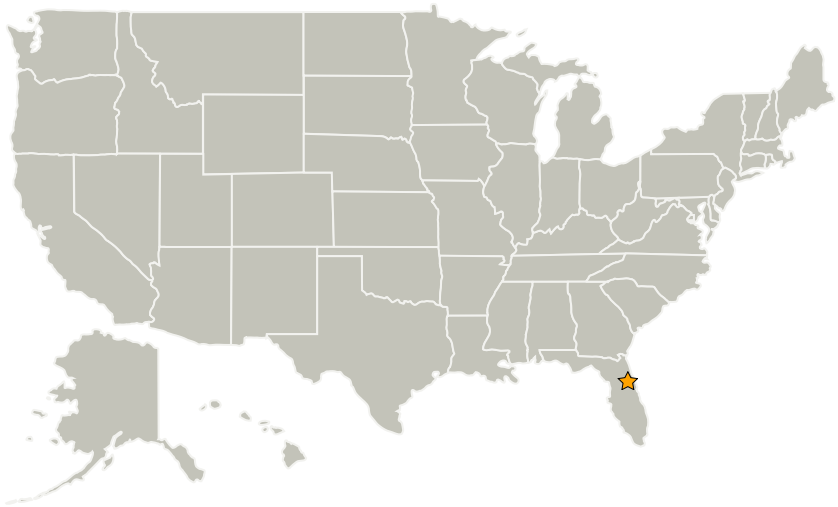
the object. This specific task does not appear to be listed in the NASA Technology Roadmaps, however the Restore Project had an early requirement to mate to defunct satellites in order to refuel them. As the project progressed, its scope was reduced and this requirement was dropped, but the task remains.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Kennedy Space Center(KSC)	Lead Organization	NASA Center	Kennedy Space Center, Florida
Air Force Research Laboratory(AFRL)	Supporting Organization	US Government	Notre Dame, Indiana
Cornell University	Supporting Organization	Academia	Ithaca, New York

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Kennedy Space Center (KSC)

Responsible Program:

Center Innovation Fund: KSC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Barbara L Brown

Principal Investigator:

Robert C Youngquist

Co-Investigator:

Mark A Nurge

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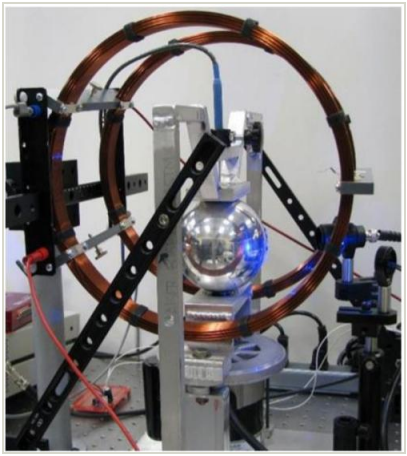
Images



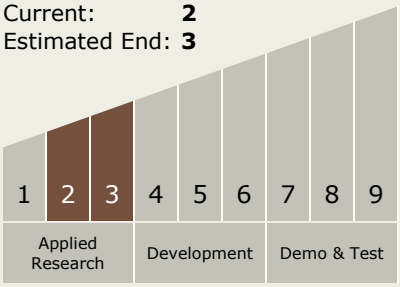
Project Image
Aluminum sphere in a uniform magnetic field.
(https://techport.nasa.gov/image/35772)

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX04 Robotic Systems
  - TX04.5 Autonomous Rendezvous and Docking
    - TX04.5.7 Modeling, Simulation, Analysis, and Test of Rendezvous, Proximity Operations, and Capture

Target Destination

Earth